Tue 16:30 Saint Pierre Cardiovascular ultrasound image and signal analysis: a powerful tool toward valid, non-invasive and low-cost disease diagnosis

4D Ultrafast ultrasound imaging of the heart: towards non invasive quantification of myocardial stiffness – (Invited, 000565)

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Cardiac pathologies are often characterized by a significant change of myocardial stiffness, re-organization of muscle fiber structure, and the accompanying dysfunction, all of which remain challenging to be quantitatively assessed in vivo. Ultrafast imaging is a novel ultrasonic imaging approach developed at Institut Langevin that provides images of the heart at thousands of images/s. Based on ultrafast imaging, Shear Wave Imaging (SWI) was developed to provides real-time mapping of myocardial viscoelastic properties. The technique relies on two successive steps: first, a shear wave is remotely induced in the myocardium using the acoustic radiation force of a focused beam, and second, the shear wave propagation is imaged using ultrafast imaging (10,000 images per seconds). The shear modulus is derived from the shear wave speed. SWI is applied to the evaluation of myocardial stiffness on animal models of cardiomyopathy. The dynamics of change in shear modulus during the cardiac cycle is measured and the relationship between the viscoelastic properties and physiological parameters such as contractility in normal and infarcted myocardium is investigated. In addition, the myocardial fiber orientation can be mapped by exploiting the anisotropy of shear wave propagation. Finally, a novel 4D ultrafast imaging platform is developed to provide thousands of volumes per second of the heart. Ultrafast imaging as well as SWI are performed in vivo in 4D using a single acquisition performed during one cardiac cycle.

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The role of multiphysics modeling in establishing a robust ultrasound-based cardiovascular risk assessment – (Invited, 000575)

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Arterial stiffness has proven to be a powerful, early marker of cardiovascular diseases, with prognostic value beyond the classical risk factors like smoking, high blood pressure, cholesterol,... However, local evaluation of arterial stiffness remains technically challenging despite a wide range of non-invasive, ultrasound-based techniques developed for this purpose. Hence, we have been investigating the performance of ultrasonic measurement strategies for arterial stiffness, both from a biomechanical and image acquisition perspective. In particular, we have been studying direct tissue characterization techniques as well as strategies to locally assess the arterial pulse wave velocity (PWV), i.e. the propagation speed of the arterial pulse created by the cardiac contraction as it travels through the cardiovascular network. The former class of techniques refers to our investigation of shear wave elastography, assessing tissue stiffness by tracking shear waves artificially evoked in the tissue via the acoustic energy of an ultrasound probe. Local PWV can be non-invasively assessed in multiple ways, e.g. as the slope of the arterial diameter (ln(D)) versus blood velocity (U) signal in early systole via ultrasonic wall tracking (D) and Doppler (U) techniques.
However, previously mentioned measurement strategies are hampered in the presence of intricate vascular anatomy or tissue mechanics, inducing complex pulse/shear wave phenomena, erroneously affecting stiffness assessment. Hence, we developed a computer modeling platform for in-depth investigation and validation of these measurement strategies, allowing comparison of the simulated measurement outcome with the true tissue properties, fully defined in the simulation but typically lacking during in-vitro/in-vivo evaluation. Hence, this is a multi-physics model, integrating both the biomechanics and imaging, which has allowed us to analyze arterial stiffness assessment techniques in varying biomechanical conditions as well as to investigate new imaging approaches and signal processing.

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Automatic emboli detection system for the artificial heart – (Contributed, 000362)

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